1933

Economic studies of Cochliomyia macellaria Fab with special reference to the prevention of myiasis of domestic animals

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NOTE TO USERS

ECONOMIC STUDIES OF COCHLIOMYIA MACELLARIA FAB. WITH SPECIAL REFERENCE TO THE PREVENTION OF MYIASIS OF DOMESTIC ANIMALS

BY

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A Thesis Submitted to the Graduate Faculty
for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject Entomology

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Iowa State College

1933

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ACKNOWLEDGEMENTS

My acknowledgements are many. First, I wish to acknowledge the collaboration of Messrs. E. C. Cushing and H. E. Parish, Assistant Entomologists, U. S. Bureau of Entomology, who collected much of the data presented herein. And to over seventy-five ranchmen of Menard County, Texas, my acknowledgements are due for the thousands of case records which they supplied. Without their wholehearted cooperation this investigation would not have been possible.

INTRODUCTION

Cochliomyia macellaria Fabricius, the New World screw-worm fly, or more commonly called the Texas screw-worm fly, is a species of the blow-fly family Calliphoridae. It belongs to that myiasis-producing group of Diptera, the females of which, though normally laying their eggs or depositing their larvae in decaying animal and vegetable matter, will lay their eggs or deposit their larvae on either broken or unbroken skin, mucous membranes, and diseased tissues or wounds. As a whole, this is a group of obligatory necrobiots, but some of its members, especially Cochliomyia macellaria, are also well adapted facultative sarcobiots.

Myiasis is the condition resulting from the invasion of the tissues of mammals by dipterous larvae. The types of myiasis are many. Man and many other animals are affected by one or several types of myiasis. This dissertation, however, unless otherwise stated, is entirely limited to those types produced by C. macellaria, and then only insofar as they occur in seven (7) group classes of domestic animals.

Heavy losses are suffered each year by the various livestock interests throughout the southwestern part of the United States owing to the destructive activities of the screw-worm fly. Babcock and Bennet (1921) estimated this damage at four millions of dollars annually. Parman (1925) states that the loss in some years is five millions of dollars, and according to Laake and Cushing (1930) southwestern ranchmen estimated their losses in 1928 due to the screw-worm and fleece worm at ten millions of dollars.

Screw-worm flies are strongly attracted to the slightest wound or diseased tissue of an animal. Either the living or necrotic tissues of the host are favorable sites for the deposition of ova. The feeding of the resulting larvae causes a rapid destruction of the tissues involved and very often death within a few days if treatment is not promptly administered.

Parman (1925) reports the results of extensive experiments with larvicides for killing the larvae in wounds of animals. Bishopp et al (1925), Parman et al (1927) (1928) and Laake et al (1926) studied the chemotropic responses of the screw-worm fly to numerous chemicals with the object of finding a material suitable for wound application and of a strong and lasting repellent power for the protection of the wound from reinfestation. Their studies have yielded valuable information on suitable materials for the destruction of the larvae in the wound and the protection of the wound from reinfestation for a reasonable length of time. Bishopp et al (1926) also point out the necessity of range sanitation to prevent the breeding of myiasis-producing species of flies and suggest modifications in the methods of range management in order to reduce myiasis during the screw-worm season. No other control methods of the screw-worm fly or methods of preventing myiasis caused by it have been investigated or reported according to available literature.

Considering the great economic importance of this problem and the lack of reliable quantitative data on certain methods of control, it is evident

that further and more exhaustive studies on the predisposing causes of myiasis and the possibility of controlling the screw-worm fly by systematic trapping are urgently needed.

During the screw-worm seasons of 1929 to 1932, inclusive, a rather extensive study of the predisposing causes of myiasis in domestic animals was conducted; during 1931 and 1932 the effect of systematic trapping in the reduction of myiasis was investigated. Studies designed to test the efficiency of several types of blowfly traps, baits, and desirable trap locations also were conducted during the seasons of 1929 to 1932, inclusive, but these data are not included in this report. The studies reported in this paper comprise a part of the investigations prosecuted by the Division of Insects Affecting the Health of Man and Animal, Bureau of Entomology, United States Department of Agriculture.

METHODS AND MATERIAL

In the study designed to determine the predisposing causes which render animals susceptible to attack by the screw-worm fly, over seventy-five (75) ranches located in Menard, Kimble, and Schleicher counties, Texas, constituted the locality in which this investigation was made. Each ranch operator was provided with printed forms on which to record each new case of myiasis. The data of each case recorded consisted of the date of the case, the class of animal infested, and the predisposing cause of the infestation. The injury sustained or the condition responsible for each new case was determined as nearly accurately as possible by the ranchman. The age of the animal and the methods locally employed for the handling of animals of different ages constituted the basis for the grouping of animals of the same or closely related species into different classes.

The fly traps used were those generally known as the "Government all-metal cone type". A full description of this type of trap is given in Farmers' Bulletin No. 734, United States Department of Agriculture. Grey enameled bait pans, 3-3/4 to 4 inches deep by 13 inches in diameter at the top, with a bait capacity of approximately 7 quarts, were used. The bait used consisted of fresh goat or sheep meat and water. Nicotine sulphate at the rate of 3 to 4 cc. per gallon of water was added to the bait to prevent the breeding of larvae in the bait pans. The amount of bait used for each trap and the baiting schedule adopted for both the 1931 and 1932 seasons were as follows: 2 pounds of meat and approximately 6 quarts of

water containing the nicotine sulphate were placed in each bait pan at the beginning of the season. The pans were cleaned and rebaited at fourteen (14) to twenty-six (26) day intervals, depending upon temperature and rate of evaporation. One pound of meat and the amount of evaporated water were added on the seventh to thirteenth day, or about the middle of the bait exposure period. No nicotine sulphate was added to the water used for the refill. (Previous experiments determined that the addition of one pound of meat and the refill of fluid which had evaporated in each bait pan at about the half way point of each complete bait exposure period activated the bait left in the pans at the time of the refill approximately to its original attrahent efficiency for the entire period and resulted in a saving of one pound of meat for each trap for each complete bait exposure period throughout the season.) The rate of decomposition of the meat and the evaporation of the water is greatly accelerated during the heat of the summer months or during extended periods of continuous high winds. It is obvious, therefore, that no predetermined set schedule of maintenance of the traps could be followed in order to secure the greatest efficiency from them throughout the variable climatic seasons of screw-worm activity.

Each trap was placed on a triangular wooden platform which was nailed approximately 4 feet above the ground between two trees. The legs of the trap were fastened to the platform in order to prevent disturbance by animals or high winds. The location of each trap was carefully selected, and the trap platforms were leveled and fastened to trees of sufficient size

to prevent any considerable amount of swaying during high winds in order to prevent spilling of the bait.

The area trapped consisted of 154,879 acres in 1931 and 155,679 acres in 1932. This area is in the Edwards Plateau region and is comprised of typical west Texas ranch land in the northwestern part of Menard County, Texas along the north side of the San Saba River, which properly begins in springs in the vicinity of Fort McKavett, situated at the southwestern corner of this area. The elevation varies from 1950 to about 2200 feet above sea level. The rainfall averaged approximately 22.8 inches per year for six years, according to unofficial local records. The topography ranges from gently rolling and hilly to moderately rough and broken land. The ridges and often the hillsides throughout this area are very stony. There are few running streams other than the San Saba River, but numerous shallow, dry creeks and draws separate the hills. The vegetation consists of clustered and scattered live oak, chin oak, mesquite trees of small to medium size, and various small, thorny shrubs. Various weeds and grasses grow luxuriantly along the draws and hillsides when rainfall is sufficient. There is little cultivation, less than 1 per cent, in the area in question.

664 traps were rather uniformly distributed over the test area at an average rate of one trap for approximately every 234 acres, or nearly 2.74 traps per section based on the 1932 average. The traps were operated from March 1 to October 31 of each of the two years. Approximately every twenty-one (21) days all the dead flies which had accumulated in the traps were removed and measured.

The control or non-trapped area consisted of 144,860 acres in 1931 and 172,000 acres in 1932. The ranches in this area were somewhat scattered and were situated in the southern portion of Menard County, in the northern portion of Kimble County, and in the west central portion of Schleicher County. The elevation, topography, vegetation, precipitation, etc., in the localities in which the various ranches comprising the non-trapped area were located are very similar to those in the trapped area. Also the management of the ranches and the seasonal methods of range practice are very similar in the aggregate for both areas.

The animal population of every ranch was recorded at monthly intervals and averaged at the end of the season for each class of animals on each ranch in both areas.

All cases of myiasis in both areas were recorded on the cards described above. These records were collected from each ranch approximately every six (6) to eight (8) days throughout the season. The person on each ranch detailed to the duty of determining the predisposing causes of myiasis, the class of animal affected, etc., is, in the light of many years' experience, thoroughly competent to do this task accurately in most cases. Occasionally, however, cases were not promptly recorded and it was, therefore, made a rule to question the recordkeeper weekly on each ranch to ascertain if any cases were not recorded. If the case records were not complete, a record for each of the cases missed was then made. The person questioned usually was able to give a complete history of the unrecorded cases, but

in case of doubt as to the predisposing cause of the infestation or the class of animal infested, the record was marked as questionable and was not included in the data presented herein.

The so-called jar method was used in the study of the relative reduction of the screw-worm fly in the trapped area. Briefly, this method is as follows: A quart Mason jar containing 6 ounces of decomposing beef liver on 3 inches of slightly moist sand was exposed exactly ten (10) minutes, at the end of which time all flies in the jar were killed and the number and per cent of each species determined. Ten (10) exposures a day were made in selected and widely distributed locations in each area at approximately thirty (30) day intervals in 1931, and twenty (20) exposures a day at approximately fifteen (15) day intervals in 1932. The relative abundance of each species was determined by comparing the total number of each species caught in the trapped area with that caught in the non-trapped area.

EXPERIMENTAL DATA

An enormous volume of data have been collected during the course of this investigation, especially with reference to the trapped area, where records were made of each trap, each case of myiasis and certain ecological factors in relation to myiasis incidence. To present all this information in detail would require too much space and it has, therefore, seemed advisable to include in this report only the most important data. To conserve space further the monthly records were combined into seasonal summaries, which are presented in tables and graphs.

The experimental data are presented in two parts as follows:

Part A - Predisposing Causes of Myiasis;

Part B - Systematic Trapping of the Screw-worm Fly.

Part A

Predisposing Causes of Myiasis

The purpose of this investigation was to determine the relative importance of the predisposing causes of myiasis in seven (7) classes of domestic animals with the hope of suggesting modifications of range practices in order to reduce or eliminate such causes.

The extensiveness of the number of observations over a period of four (4) years is given in tabular form below:

Year	No. Ranches	No. Acres	Aver. Monthly Animal Population	No. of Cases Myiasis
1929	35	173,185	116,361	3,332
1930	34	167,879	104,386	1,442
1931	70	299,739	187,050	4,055
1932	68	327,679	193,444	8,315

The predisposing cause of each new case of myiasis was determined as nearly accurately as possible by the ranchmen. In every case where the predisposing cause was uncertain, due to the fact that the infested animal was not found until the infestation had spread and the destruction of the tissues had become so extensive that the nature of the predisposing cause was no longer evident, it was recorded as unknown. Such unknown predisposing causes are not included in the tables or the graphs. Tables Nos. 1 to 7 and Figs. Nos. 1 to 7 show the predisposing causes of myiasis for each class of animals and their relative importance as recorded during the period from March 1 to October 31 of the four (4) years in question.

Table No. 1

Showing the Predisposing Causes of 5,249 Cases of Myiasis in Sheep

Predisposing Causes	Number of Cases
Needle grass	1,619
Fighting	1,526
Horn flies	725
Shear cuts	612
Accidental injuries	278
Prickly pear (cactus)	111
Birth	104
Sore mouth	81
Udder injuries	41
Boils	38
Dehorning	34
Beggar lice (seed)	21
Broken horns	16
Rock-bruised feet	9
Brush scratches	7
Wire cuts	6
Old sores	6
Dog bite	3
Hooked by cattle	3
Marking	3
Genitalia injuries	3
Castrating	1
Lice	1
Ticks	1

Table No. 2

Showing the Predisposing Causes of 1,841 Cases of Myiasis in Lambs

Predisposing Causes	Number of Cases
Needle grass	549
Docking	386
Sore mouth	237
Marking	230
Horn flies	135
Birth	104
Castrating	91
Accidental injuries	80
Beggar lice (seed)	6
Brush scratches	6
Lice	4
Broken horns	3
Fighting	3
Shear cuts	2
Tooth decay	1
Boils	1
Dehorning	1
Hog bite	1
Prickly pear (cactus)	1

Table No. 3

Showing the Predisposing Causes of 3,959 Cases of Myiasis in Goats

Predisposing Causes	Number of Cases
Shear cuts	2,656
Boils	368
Brush scratches	314
Accidental injuries	281
Lice	74
Broken horns	38
Needle grass	32
Udder injuries	32
Warts	24
Horn flies	22
Castrating	17
Beggar lice (seed)	17
Prickly pear (cactus)	16
Birth	16
Fighting	14
Wire cuts	12
Dog bite	6
Hooked by cattle	5
Branding	4
Ticks	3
Sore mouth	2
Broken leg	2
Tooth decay	1
Rock-bruised feet	1
Old sores	1
Scours	1

Table No. 4

Showing the Predisposing Causes of 357 Cases of Myiasis in Kids

Predisposing Causes	Number of Cases
Shear cuts	162
Castrating	47
Accidental injuries	43
Birth	32
Brush scratches	22
Marking	18
Lice	13
Boils	4
Broken horn	3
Hog bite	3
Beggar lice (seed)	3
Needle grass	2
Tooth decay	1
Dog bite	1
Hooked by cattle	1
Horn flies	1
Sore mouth	1

Table No. 5

Showing the Predisposing Causes of 1,643 Cases of Myiasis in Cattle

Predisposing Causes	Number of Cases
Hooked	644
Horn flies	360
Accidental injuries	190
Birth	171
Horse flies	61
Wire cuts	54
Cancer eye	46
Dehorning	23
Fighting	14
Boils	13
Warts	12
Udder injuries	10
Broken horns	9
Branding	7
Brush scratches	7
Ox warbles	6
Pink eye	5
Castrating	4
Genitalia injuries	2
Marking	1
Old sores	1
Snake bite	1
Ticks	1
Prickly pear (cactus)	1

Table No. 6

Showing the Predisposing Causes of 3,516 Cases of Myiasis in Calves

Predisposing Causes	Number of Cases
Birth	2,299
Castrating	389
Dehorning	328
Horn flies	134
Hooked	128
Accidental injuries	99
Marking	29
Branding	26
Wire cuts	24
Boils	18
Warts	11
Horse flies	11
Broken horns	4
Ticks	4
Cancer eye	3
Needle grass	2
Snake bite	2
Old sores	1
Sore mouth	1
Brush scratches	1
Rope burn	1
Pink eye	1

Table No. 7

Showing the Predisposing Causes of 358 Cases of Myiasis in Horses and Mules

Predisposing Causes	Number of Cases
Wire cuts	218
Accidental injuries	69
Genitalia injuries	33
Birth	14
Rope burn	9
Brush scratches	4
Stud bites	4
Boils	1
Branding	1
Hocked by cattle	1
Saddle sores	1
Snake bite	1
Bruised foot	1
Spaying	1

Part B

Systematic Trapping of the Screw-worm Fly

The principal objectives of this investigation were to determine:

1) The effect of systematic trapping of the screw-worm fly on the reduction of myiasis in domestic animals.

2) The approximate per cent of reduction of the screw-worm fly in an extensive area under systematic trapping.

Tests of 1931

The number of cases of myiasis, animal population, animal concentration, percentage infestation, and numbers of traps for each of the fifty (50) ranches comprising the test or trapped area are shown in Table No. 8. The corresponding data representing the control or non-trapped area are presented in Table No. 9. A comparison of the average animal concentration and the average percentage infestation in both the trapped and control areas, together with a condensed summary of the data in Tables Nos. 8 and 9, are shown in Table No. 10.

The comparative abundance of C. macellaria in the two areas as determined by the jar method is shown in Table No. 11. These data, together with the per cent reduction of C. macellaria in the trapped area, are shown in Fig. No. 8.

Table No. 8

Showing Number of Cases of Myiasis in the Trapped Area from March 1 to October 31, 1931

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps	Total No. of Cases	Percentage Infestation All Animals
1	1,280	1,364	1.07	6	49	3.59
2	1,280	570	.45	6	16	2.81
3	4,700	1,564	.33	22	16	1.02
4	640	367	.57	4	1	.27
5	2,560	3,058	1.19	12	54	1.77
6	3,200	2,415	.75	10	54	2.24
7	3,200	2,667	.83	15	78	2.92
8	5,120	5,024	.98	24	57	1.13
9	5,434	5,791	1.07	26	54	.93
10	9,980	8,376	.84	47	143	1.71
11	1,280	1,378	1.08	6	29	2.10
12	9,920	5,016	.51	31	80	1.59
13	11,200	5,523	.49	52	106	1.92
14	9,600	5,711	.59	60	120	2.10
15	9,920	4,983	.50	45	57	1.14
16	1,280	1,394	1.09	6	29	2.08
17	3,840	2,781	.72	18	77	2.77
18	4,800	3,714	.77	30	57	1.53
19	1,280	865	.68	8	6	.69
20	3,200	2,120	.66	15	17	.80
21	1,400	1,659	1.19	7	8	.48
22	320	188	.59	2	6	3.19
23	800	1,108	1.39	4	17	1.53
24	3,200	2,113	.66	5	10	.47
25	1,920	1,428	.74	6	0	.00
26	151	193	1.28	1	1	.52
27	294	181	.62	1	2	1.10
28	1,000	648	.65	4	6	.93
29	1,100	620	.56	7	39	6.29
30	2,000	409	.20	15	5	1.22
31	320	190	.59	2	13	6.84
32	320	210	.66	2	29	13.81
33	3,200	3,355	1.05	15	22	.66
34	5,120	2,472	.48	16	62	2.51
35	1,600	2,184	1.37	5	27	1.24

Table No. 8 (Cont'd.)

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps	Total No. of Cases	Percentage Infestation All Animals
36	1,200	847	.71	7	8	.94
37	640	398	.62	2	7	1.76
38	640	353	.55	2	8	2.27
39	8,220	5,679	.69	26	56	.97
40	960	705	.73	3	4	.57
41	5,120	1,229	.24	16	98	7.97
42	2,560	1,015	.40	8	14	1.38
43	1,000	799	.80	5	9	1.13
44	2,560	2,336	.91	8	12	.51
45	1,280	1,366	1.07	4	14	1.02
46	480	424	.88	2	3	.71
47	9,280	4,183	.45	29	35	.84
48	640	517	.81	2	7	1.35
49	1,920	1,612	.84	6	16	.99
50	1,920	1,687	.88	6	17	1.01
Total	154,879	104,789	--	661	1,654	--

Table No. 9

Showing Number of Cases of Myiasis in the Control Area
from March 1 to October 31, 1931

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	Total No. of Cases	Percentage Infestation All Animals
1	11,000	9,530	.87	257	2.70
2	3,200	2,612	.82	106	4.06
3	2,560	2,528	.99	82	3.24
4	400	452	1.13	12	2.65
5	3,840	2,929	.76	147	5.02
6	18,000	6,019	.32	245	4.07
7	3,200	2,313	.72	76	3.29
8	4,000	2,407	.60	55	2.29
9	2,800	2,324	.83	31	1.33
10	5,080	4,328	.85	52	1.20
11	400	442	1.11	10	2.26
12	10,000	1,984	.20	130	6.55
13	2,880	3,104	1.07	33	1.06
14	3,000	2,692	.90	163	6.05
15	3,520	2,466	.70	68	2.76
16	12,800	12,948	1.01	235	1.81
17	20,480	13,209	.64	260	1.97
18	1,600	2,064	.98	42	2.03
19	2,100	2,313	.91	23	.99
20	34,000	5,597	.16	374	6.68
Total	144,860	82,261	--	2,401	--

Table No. 10

Showing the Average Concentration and Percentage Infestation of All Animals in the Trapped and Control Areas for the Period March 1 to October 31, 1931

Area	No. of Ranches	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps in Area	No. of Cases in All Animals	Percentage Infestation All Animals
Trapped	50	154,879	104,789	.68	661	1,654	1.58
Control	20	144,860	82,261	.57	0	2,401	2.92

Table No. 11

Showing Relative Abundance of C. macellaria in the Trapped and Control Areas as Determined by the Jar Method for the Period April 10 to November 6, 1931

Date of Observation	No. of C. macellaria in 10 Jar Exposures	
	Trapped Area	Control Area
April 10	1	16
May 9	187	858
June 9	54	108
July 10	4	88
July 24	69	1,220
August 14	22	89
September 9	26	365
October 8	165	331
November 6	22	334

Tests of 1932

The tests of 1931 were repeated with slight changes in the acreage, total animal population, and number of traps.

The number of cases of myiasis, average monthly population of all classes of animals, concentration of animals, number of traps, and percentage infestation for each of the fifty-one (51) ranches in the trapped area are shown in Table No. 12. The corresponding data from each of the seventeen (17) ranches in the control area are presented in Table No. 13. The average concentration and percentage infestation of all animals for all of the ranches combined from both the trapped and control areas are shown in Table No. 14.

The comparative abundance of C. macellaria in the two areas as determined by the jar method is shown in Table No. 15. These data, together with the per cent reduction of C. macellaria in the trapped area, are shown in Fig. No. 9.

Table No. 12

Showing Number of Cases of Myiasis in the Trapped Area from March 1 to October 31, 1932

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps	Total No. of Cases	Percentage Infestation All Animals
1	5,120	2,432	.48	16	228	9.38
2	1,280	1,623	1.27	6	45	2.77
3	1,280	1,346	1.05	6	38	2.82
4	480	509	1.06	2	13	2.55
5	4,700	1,617	.34	22	22	1.36
6	151	237	1.57	1	0	.00
7	294	350	1.19	1	24	6.86
8	1,920	1,233	.64	6	19	1.54
9	3,200	2,434	.76	5	33	1.36
10	320	237	.74	2	15	6.33
11	5,120	1,564	.31	16	86	5.50
12	2,560	1,295	.51	8	69	5.33
13	1,100	949	.86	7	178	18.76
14	640	341	.53	4	16	4.69
15	2,560	4,167	1.63	12	91	2.18
16	320	187	.58	2	15	8.02
17	9,280	5,416	.58	29	243	4.49
18	1,000	940	.94	4	39	4.15
19	3,200	2,363	.74	10	40	1.69
20	2,560	2,519	.98	8	79	3.14
21	1,280	1,263	.99	4	15	1.19
22	3,200	2,294	.72	15	133	5.80
23	640	482	.75	2	68	14.11
24	3,200	3,330	1.04	15	108	3.24
25	640	455	.71	2	12	2.64
26	5,434	6,825	1.26	26	120	1.76
27	1,400	1,930	1.38	7	24	1.24
28	800	170	.21	2	0	.00
29	5,120	4,431	.87	24	87	1.96
30	1,000	766	.77	5	26	3.39
31	1,200	1,626	1.36	7	90	5.54
32	9,980	9,184	.92	47	220	2.40
33	1,280	1,423	1.11	6	156	10.96
34	9,920	6,482	.65	31	284	4.38
35	2,000	346	.17	15	30	8.67

Table No. 12 (Cont'd.)

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps	Total No. of Cases	Percentage Infestation All Animals
36	1,600	2,132	1.33	5	59	2.77
37	1,920	1,894	.99	6	52	2.75
38	960	843	.88	3	12	1.42
39	8,220	11,543	1.40	26	103	.89
40	640	400	.63	2	52	13.00
41	11,200	6,402	.57	52	262	4.09
42	9,600	5,748	.60	60	195	3.39
43	1,920	1,994	1.04	6	48	2.41
44	800	1,116	1.40	4	41	3.67
45	9,920	5,642	.57	45	177	3.14
46	1,280	1,763	1.38	6	66	3.74
47	3,840	2,830	.74	18	176	6.22
48	4,800	3,272	.68	31	133	4.06
49	3,200	3,618	1.13	15	110	3.04
50	320	266	.83	2	5	1.88
51	1,280	753	.59	8	29	3.85
Total	155,679	122,982	--	664	4,186	--

Table No. 13

Showing Number of Cases of Myiasis in the Control Area
from March 1 to October 31, 1932

Ranch No.	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	Total No. of Cases	Percentage Infestation All Animals
1	11,000	5,416	.49	301	5.56
2	4,000	1,870	.47	103	5.51
3	3,200	2,773	.87	89	3.21
4	3,520	2,696	.77	46	1.71
5	2,560	2,419	.94	120	4.96
6	400	387	.97	15	3.88
7	3,840	2,246	.58	109	4.85
8	18,000	9,600	.53	248	2.58
9	1,600	1,808	1.13	202	11.17
10	20,480	13,047	.64	577	4.42
11	3,000	3,562	1.19	161	4.52
12	34,000	4,194	.12	821	19.58
13	4,000	3,580	.90	101	2.82
14	400	428	1.07	27	6.31
15	10,000	2,130	.21	179	8.40
16	48,000	11,658	.24	922	7.91
17	4,000	2,648	.66	108	4.08
Total	172,000	70,462	--	4,129	--

Table No. 14

Showing the Average Concentration and Percentage Infestation of All Animals in the Trapped and Control Areas for the Period March 1 to October 31, 1932

Area	No. of Ranches	No. of Acres	Aver. No. of All Animals per Month	Aver. No. of All Animals per Acre	No. of Traps in Area	No. of Cases in All Animals	Percentage Infestation All Animals
Trapped	51	155,679	122,982	.79	664	4,186	3.40
Control	17	172,000	70,462	.41	0	4,129	5.86

Table No. 15

Showing Relative Abundance of C. macellaria in the Trapped and Control Areas as Determined by the Jar Method for the Period March 30 to October 29, 1932

Date of Observation	No. of C. macellaria in 20 Jar Exposures	
	Trapped Area	Control Area
March 30	0	8
April 16	26	19
May 3	381	670
May 19	126	869
June 8	674	1,301
June 26	437	2,184
July 14	143	1,484
July 29	79	223
August 16	246	1,059
August 30	68	140
September 15	617	4,734
October 6	5,841	7,086
October 29	73	855

DISCUSSION

Part A - Predisposing Causes of Myiasis

In view of the great number of cases recorded and the number of years during which the observations were made, it is certain that all the common and most of the uncommon predisposing causes of myiasis in seven (7) classes of animals, as shown in Tables Nos. 1 to 7, inclusive, have been established. It should be remembered, however, that since environments differ in various parts of the area affected by screw-worm flies, predisposing causes other than those listed herein might be encountered.

The relative importance of the predisposing causes of myiasis also was well established for each of the seven (7) classes of animals, as is shown by the diagrams in Figs. Nos. 1 to 7, inclusive. However, since there are many local or sectional variations in the area affected by the screw-worm fly, the most common predisposing causes will no doubt vary somewhat in different localities, but in view of the fact that most of the environments encountered in the test area are very similar to those existing over millions of acres of ranch land in the livestock areas of western and southwestern Texas, the results that were obtained in the area in question are applicable to most of the affected territory. It should be remembered also that the diagnosis of the nature of the wound or condition rendering the animal susceptible to attack is not always an easy matter, but in view of many years' experience the ranchmen who were detailed to this duty were thorough-

ly qualified to determine the predisposing causes. It is not likely, therefore, that the errors made by them are sufficient to change the relative importance of the predisposing causes as presented herewith.

The information obtained concerning the contributing factors responsible for the various predisposing causes indicates that it is possible to reduce greatly or eliminate some of the common and uncommon predisposing causes of myiasis in each of the seven (7) classes of animals studied. In order to avoid confusion, it seems advisable to discuss separately the factors responsible for each of the various predisposing causes in question for each class of animals as follows:

Sheep

Over 30 per cent of all predisposing causes of myiasis are due to needle grass. In areas where needle grass is common it will always be a serious factor during years of abundant rainfall. It is a well known fact among stockmen, however, that injury sustained from needle grass occurs almost entirely on the face and lower legs of sheep bearing heavy wool in which the needles become imbedded and then work into the tissues. The resulting wound renders the animal susceptible to attack. It is evident, therefore, that shearing the wool from the face and lower limbs just before the needles are formed would result in a marked decrease of myiasis. The loss in the prematurely clipped wool and the labor involved certainly would be less than that occasioned by the injuries sustained by the animal from the screw worms and from the labor and material required for treating and caring for it.

Fighting, responsible for 29 per cent of all predisposing causes of myiasis in this class, occurs mostly among bucks, and the wounds so sustained are confined to the head of the animal. Dehorning has not relieved the situation. The separation of the habitual fighters from the rest of the bucks in the flock has helped somewhat, but has not proved practicable, according to ranchers who have tried this practice. No other practicable preventive methods are known. It would seem, therefore, that fighting among bucks is not a predisposing cause that can be reduced materially.

Horn flies (Haematobia irritans Linn) are responsible for nearly 14 per cent of the predisposing causes of myiasis in this class of animal. Methods commonly practised for the control of this fly on dairy cattle are not practicable for sheep under range conditions. No other feasible methods of control of the horn fly under range conditions are known. In view of our present lack of knowledge of any practicable method of control of this fly under these conditions, it is at present impossible to reduce myiasis due to its injuries to sheep, or to other classes of range animals.

Shear cuts have been found to be responsible for over 11 per cent of all the predisposing causes of myiasis of sheep. In sheep and goat raising sections of the affected area shearing is done by Mexicans at a stipulated price per animal. In order to obtain the maximum daily wage, the shearing is done as rapidly as possible, and usually with a disregard for minor shear cuts in the tissues of the animal. Furthermore, with a few exceptions, the injuries so sustained by the animal are not treated with a repellent to protect the wound from fly attack. It is obvious that even the best shearers will occa-

sionally cut an animal and predispose it to screw-worm attack, but in the area in question it is quite certain that in the majority of cases the wounding of the animals is due to the type of clipper used, the haste and carelessness of the operator, and the lack of an application of a good repellent to the wounds before the animals are liberated from the shearing pens. If these underlying factors are eliminated, it would seem reasonable to the author to expect a 75 per cent reduction of myiasis due to shear cuts.

Accidental injuries are responsible for approximately 5 per cent of all predisposing causes of myiasis in this class of animal. Since man has no control over such injuries, the reduction of myiasis due to this predisposing cause is not likely to be realized.

Prickly pear injuries are usually confined to relatively few animals, and, in most instances, is due to the eating of the seed or so-called pear of the cactus. The spines on the epidermis of the seed cause the injury which predisposes the animal to attack by the screw-worm fly. To eliminate this predisposing cause of myiasis the habitual cactus feeders in regions where no cactus-free land is available should be marketed.

Birth as a predisposing cause of myiasis is found only on poorly managed ranches where bucks are permitted to breed the ewes at a time when the resulting lambs must be dropped during the screw-worm season. This predisposing cause is preventable, therefore, and entirely at the control of man.

Sore mouth, a disease of sheep, is the predisposing cause of over 1 per cent of all cases of myiasis in this class. Vaccination for the control of this disease is possible, but not yet practised except on badly infested ranches. This disease is, therefore, subject to elimination.

Among the less frequent predisposing causes of myiasis in sheep are dehorning, marking, and castrating. These operations will not predispose the animals to attack if they are performed at a time other than during the screw-worm season, and are, therefore, subject to elimination.

Lambs

What has been said of sheep with reference to the possibility of reducing or eliminating the predisposing causes of myiasis due to needle grass, sore mouth, marking, birth, castrating, shear cuts, dehorning, and prickly pear also applies to this class of animal.

In addition to those mentioned above, docking is one of the more common predisposing causes of myiasis for this class. It is responsible for nearly 21 per cent of all the predisposing causes listed, but is subject to elimination since this operation can be done at a time when screw-worm flies are not present.

Goats

Over two-thirds of all predisposing causes of myiasis in goats are due to shear cuts. As stated in the discussion of sheep, the wholesale injuries of shearing are due to the type of clippers used by the Mexican

shearers, the shearers' disregard of minor skin cuts in their haste to make the maximum wage, and the lack of an application of a good fly repellent to the wounds of the animal before it is liberated from the shearing pens. If these careless practices are discontinued, it is certain that 50 to 75 per cent of the cases of myiasis due to shear cuts will be eliminated.

Other predisposing causes that are subject to reduction or elimination are birth, castrating, and branding, since they can be timed or performed when screw-worm flies are not active.

Also the predisposing cause due to lice can and should be totally eliminated. The eradication of lice by the well known dipping method is possible and also of great economic importance on account of their severe and destructive injury to mohair.

Kids

In this class, shear cuts, castrating, birth, marking, and lice are responsible for over 76 per cent of all predisposing causes of myiasis. The means or methods as pointed out under sheep, lambs, and goats for the reduction or elimination of these predisposing causes of myiasis will also apply to this class.

Cattle

The most common predisposing cause of myiasis in this class is due to the injuries sustained from hooking while the animals are grazing in close quarters, crowded in pens, or crowded at feed or water troughs. Such in-

juries do not occur among dehorned animals. It seems clear, therefore, that the most common predisposing cause of myiasis in cattle is subject to elimination if all animals are dehorned while they are young and at a time of the year when blowflies are not present. Moreover, dehorning calves while they are very young is universally considered to be essential for the development of better beef animals.

Birth, which is responsible for over 10 per cent of all cases of myiasis in this class, at a time when screw-worm flies are present predisposes both cow and calf. Furthermore, a beef calf which is born late or during the screw-worm season is too young to be weaned the following winter and consequently the cow is compelled to nurse the calf when the range feed is usually insufficient to supply nourishment for her own normal requirements. Disease due to a greatly lowered resistance in a weakened and under nourished cow is often the result of these cases. The solution of this problem, together with the elimination of myiasis at birth, depends, therefore, on the selection of the proper time for the breeding period of the cows.

Other predisposing causes of myiasis subject to elimination are dehorning, branding, castrating, and marking. All these operations can and should be done during the period when screw-worm flies are absent.

Calves

Nearly two-thirds of all cases of myiasis in this class are due to birth. Almost every calf dropped during the height of the screw-worm sea-

son and a considerable percentage born at the beginning of the fly season become infested in the navel, and the animal, by licking the wound, transfers to the mouth worms which enter and destroy the gums. If the worms are not promptly removed, the teeth in the affected area are lost. Then dehorning, castrating, and when considered necessary branding and marking, must naturally follow soon after birth and at a time when they constitute excellent predisposing causes of myiasis. Furthermore, from the livestock buyers' view, a so-called late calf is not ready for the feeder the following winter and is rejected or bought at a reduced price. It is evident, therefore, that for the elimination of myiasis due to birth and certain operations which must follow, the selection of a proper time for the breeding period becomes of utmost importance for both the cow and the calf. It is true that even on the best managed ranches a few cows are bred by a stray bull at a time which will result in a birth during the screw-worm season. When this happens, myiasis after birth can be eliminated if dehorning, marking, and branding are delayed until the next screw worm free period, and if castration is performed with a Burdizzo emasculator, which does not inflict a wound.

Horses and Mules

Wire cuts represent over 60 per cent of all the predisposing causes of myiasis in this class. The careless scattering of barbed wire from fences which have been replaced during recent years by "wolf-proof" fencing for the protection of lambs and kids is apparently responsible for the high

incidence of this predisposition and appears to apply only to the sheep and goat raising section of the state. The importance of this careless practice, however, should not be overlooked in the consideration of methods aimed at the reduction or elimination of predisposing causes of myiasis for this class of animal.

The adoption of modified range practices, as suggested under the other classes of animals listed above applies to this class of animals for the reduction or elimination of myiasis due to the predisposing causes of birth, branding, and spaying.

Part B - Systematic Trapping of the Screw-worm Fly

The results of the 1931 investigation to determine the effect of systematic trapping of the screw-worm fly on the reduction of myiasis in domestic animals show that myiasis was reduced nearly 45 per cent in 104,789 animals of all classes in the trapped area as compared to 82,261 animals of all classes in the control area (see Tables Nos. 8, 9, and 10). The average reduction of the screw-worm fly in the trapped area, during the period from April 10 to November 6, 1931, as determined by the jar method, was nearly 84 per cent as compared to the control area (see Table No. 11 and Fig. No. 8). Slight variations must exist in two areas as large as these in question, but it is not likely that they would constitute more than a small relative variation in the aggregate. In the light of no other known factors of importance it seems quite clear that the reduction of both the population of screw-worm flies and the percentage infestation in the trapped area was due to systematic trapping throughout the screw-worm season.

During the season of 1932 the same investigations were repeated. Both the trapped and control areas, with the exception of additional acreage in the control area, were the same as those used the previous year. The results for 1932 show a reduction of 42 per cent in the percentage infestation of an average monthly population of 122,982 animals of all classes in the trapped area as compared to an average monthly population

of 70,462 animals of all classes in the control area (see Tables Nos. 12, 13, and 14). The average reduction of the screw-worm fly population in the trapped area, during the period from March 30 to October 29, 1932, as determined by the jar method, was over 57 per cent (see Table No. 15 and Fig. No. 9). These results, in the absence of any other known variations of importance between the two areas, again indicate that the 42 per cent reduction in myiasis and the 57 per cent reduction of the screw-worm fly population in the trapped area were due to the systematic operation of the fly traps. Although the average percentage infestation in 1932 was slightly more than double that of 1931, as shown by the data obtained in the control area for the two years in question (Tables Nos. 10 and 14), the proportion of the reduction of myiasis in the two areas remained virtually the same. This seems to indicate that trapping is equally effective during years of mild or heavy incidence of myiasis.

CONCLUSIONS

I. The predisposing causes of myiasis and their relative importance for seven (7) classes of domestic animals in the area under investigation have been established.

II. The factors or conditions responsible for several of the common predisposing causes of myiasis in all classes of animals are due to certain common methods of range practices, and can be reduced or eliminated by modifications of the methods in question.

III. The systematic operation of fly traps on an experimental area of 155,000 acres of ranch land situated in Menard County, Texas, reduced the population of screw-worm flies approximately 84 per cent and the number of cases of myiasis 48% in 1931, and 57 and 42 per cent, respectively, in 1932, as compared with a control area of similar size in the same vicinity.

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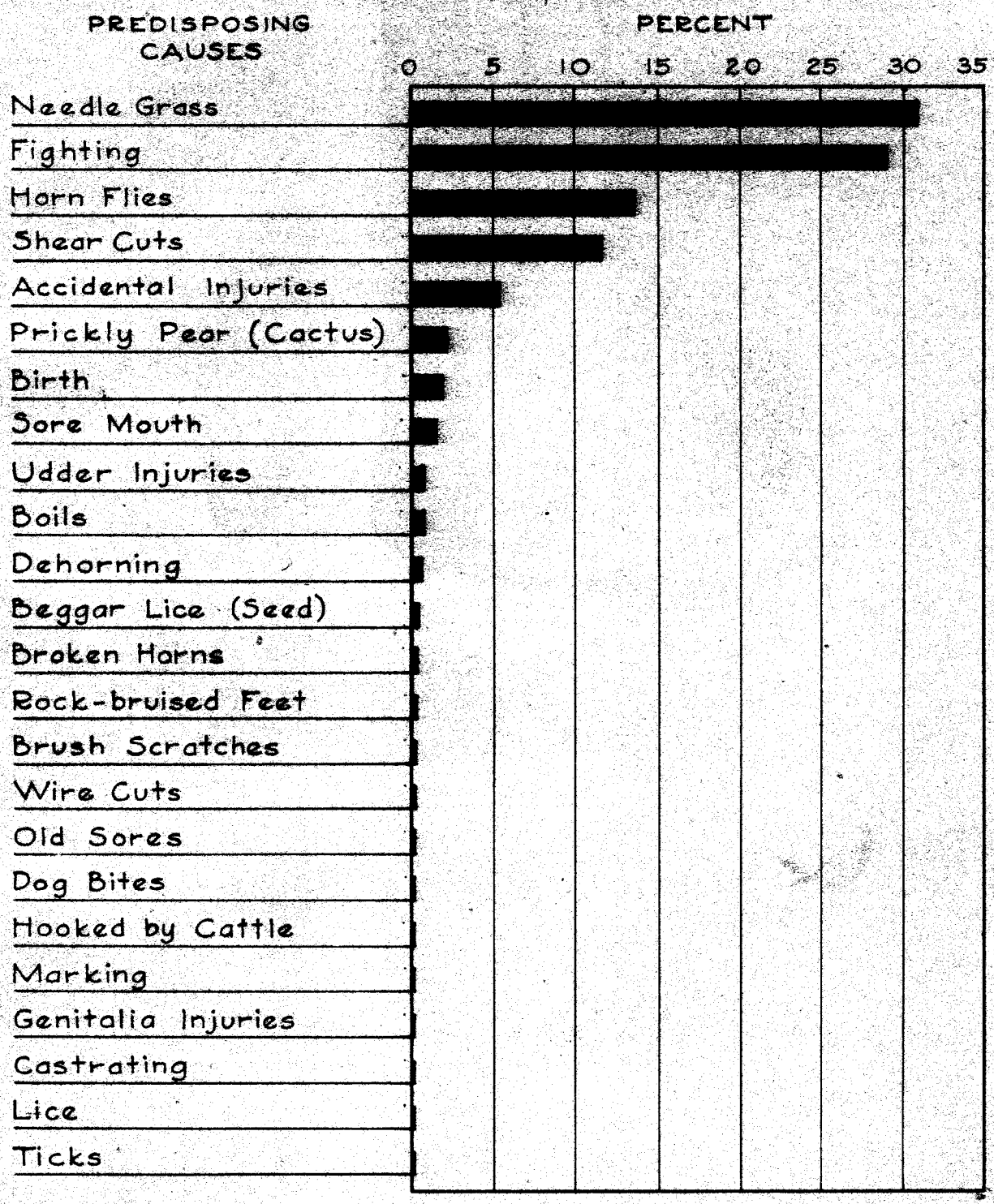

FIG. 1 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 5,249 PREDISPOSING CAUSES OF MYIASIS IN SHEEP

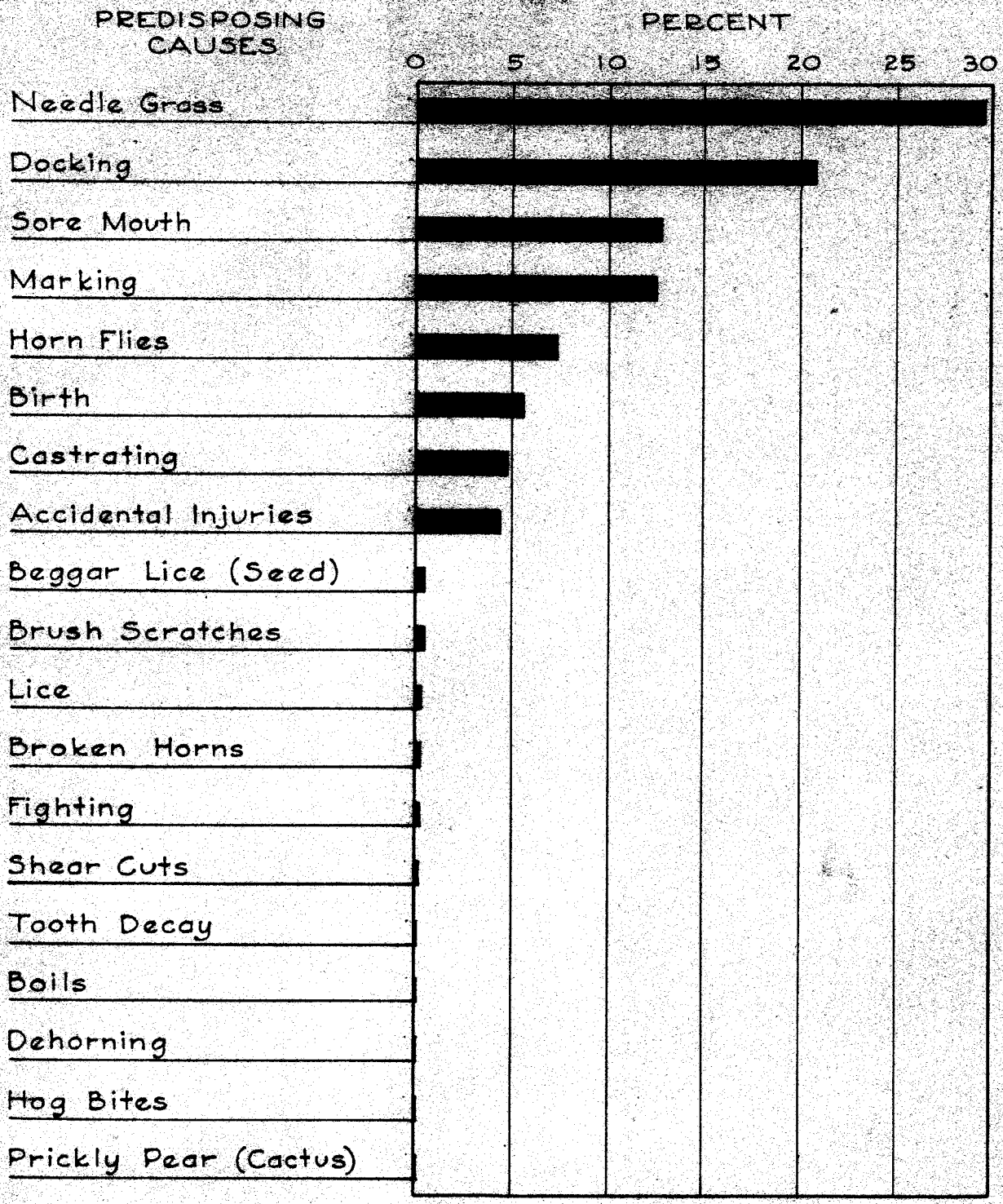

FIG. 2 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 1,841 PREDISPOSING CAUSES OF MYIASIS IN LAMBS

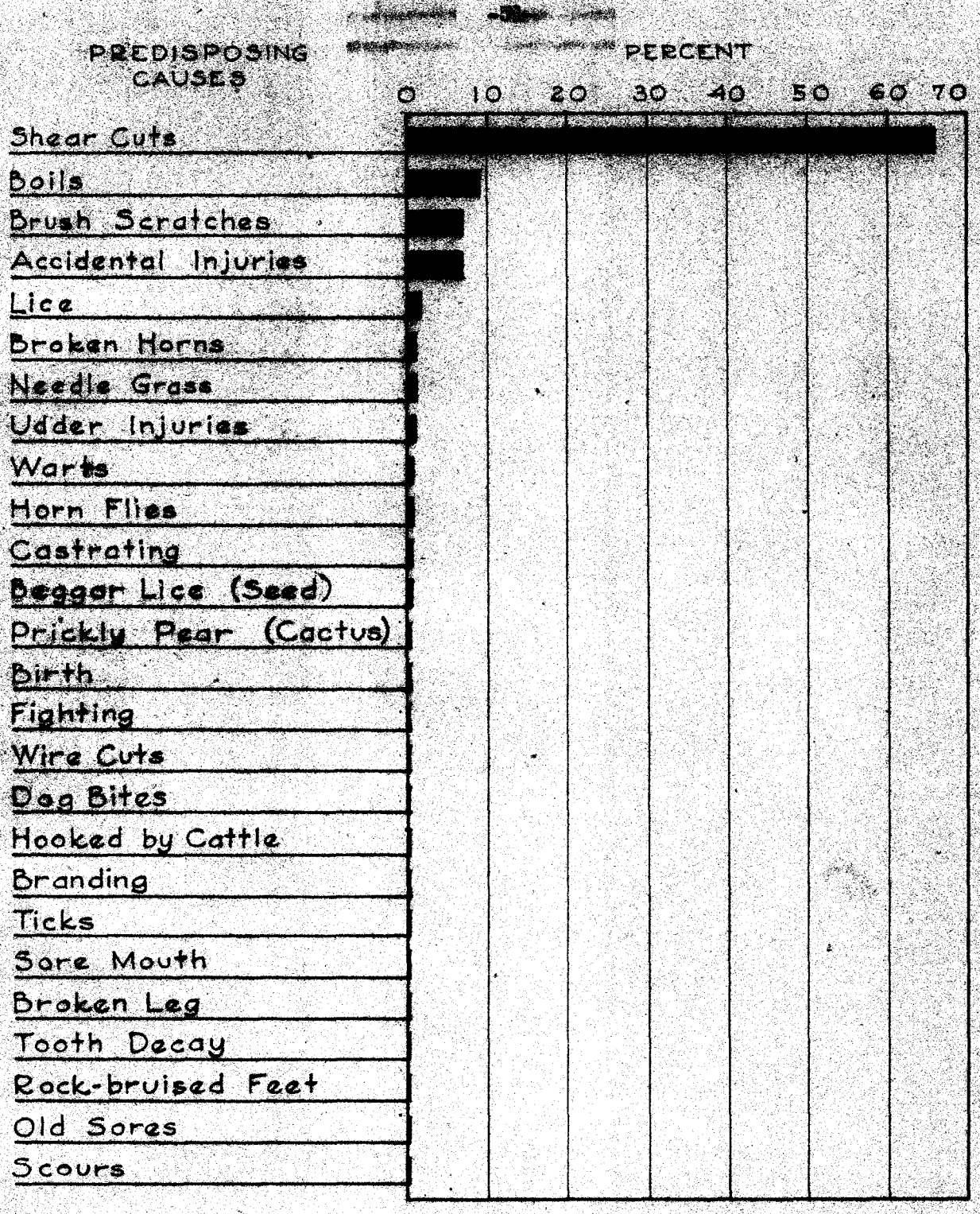

FIG 3. - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 3,959 PREDISPOSING CAUSES OF MYIASIS IN GOATS

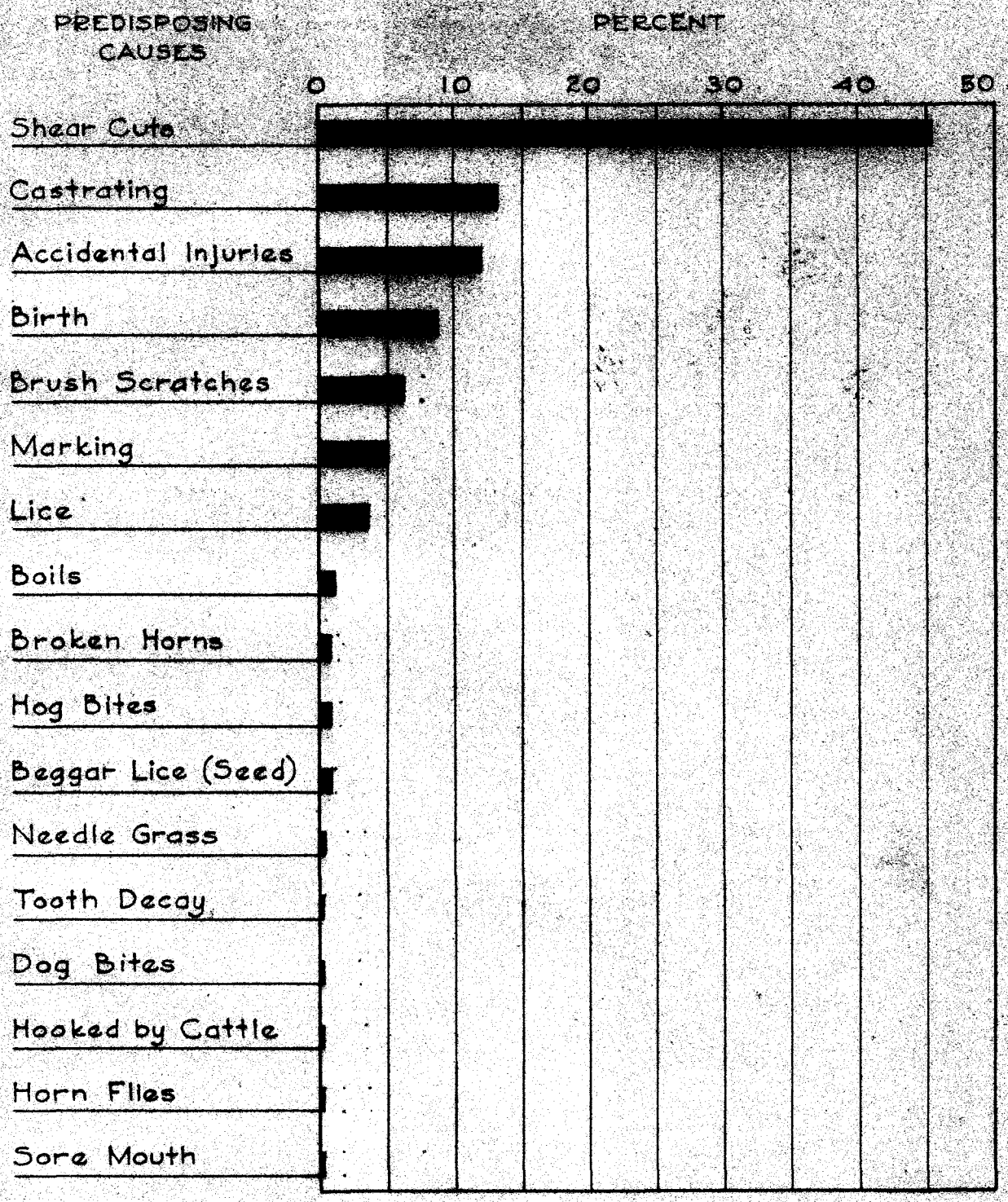

FIG. 4 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 357 PREDISPOSING CAUSES OF MYIASIS IN KIDS

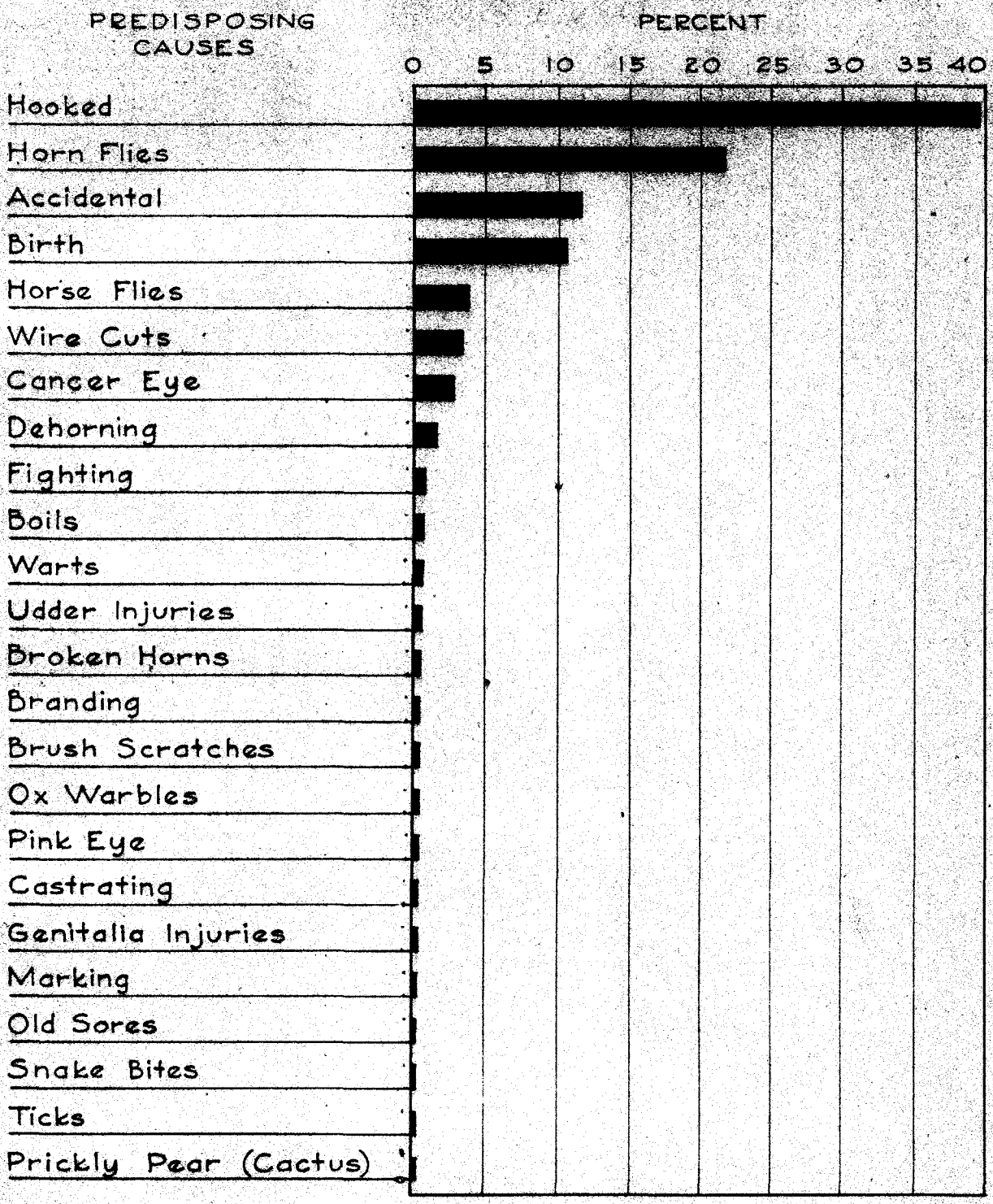

FIG. 5 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 1,643 PREDISPOSING CAUSES OF MYIASIS IN CATTLE

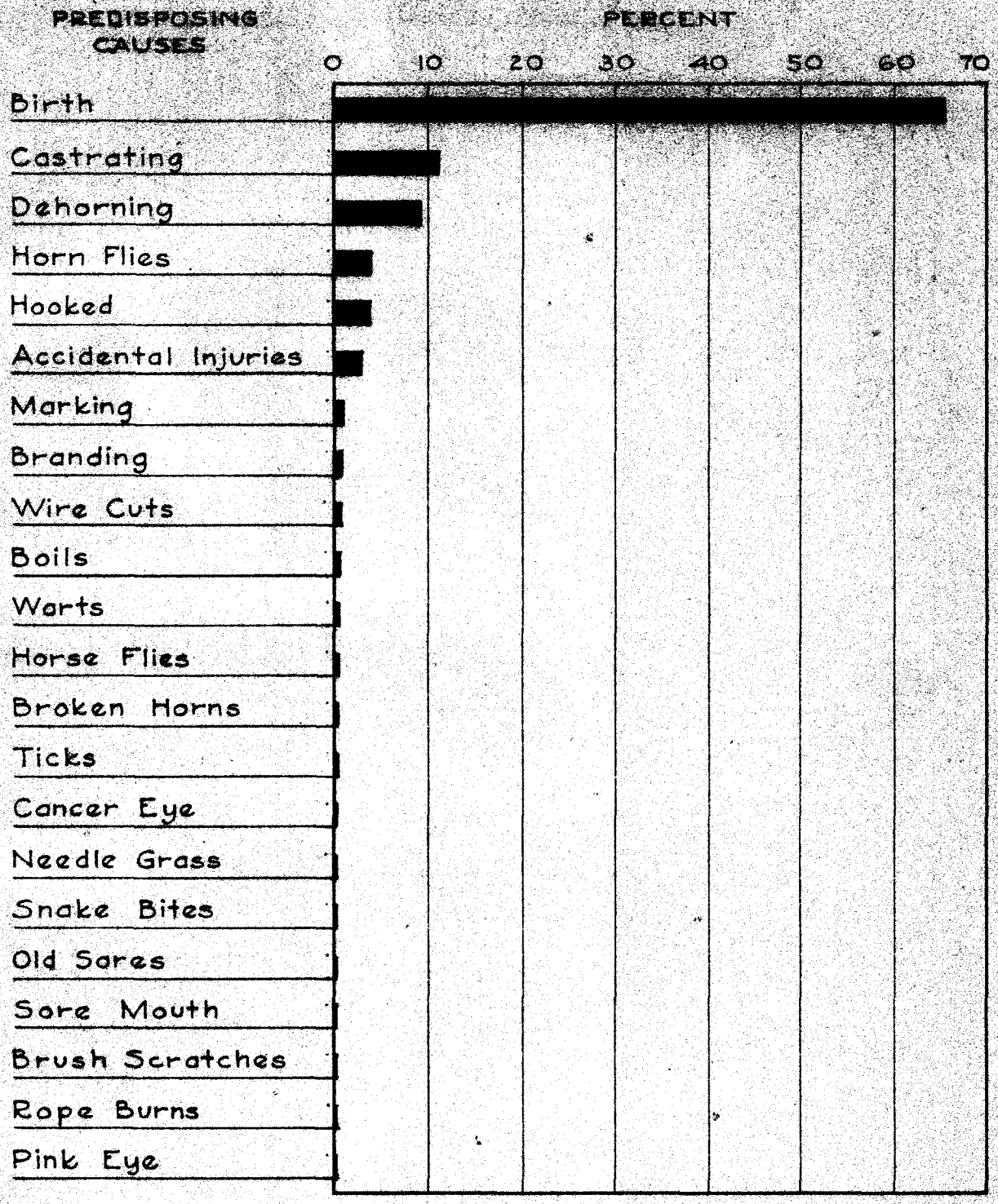

FIG. 6 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 3,516 PREDISPOSING CAUSES OF MYIASIS IN CALVES

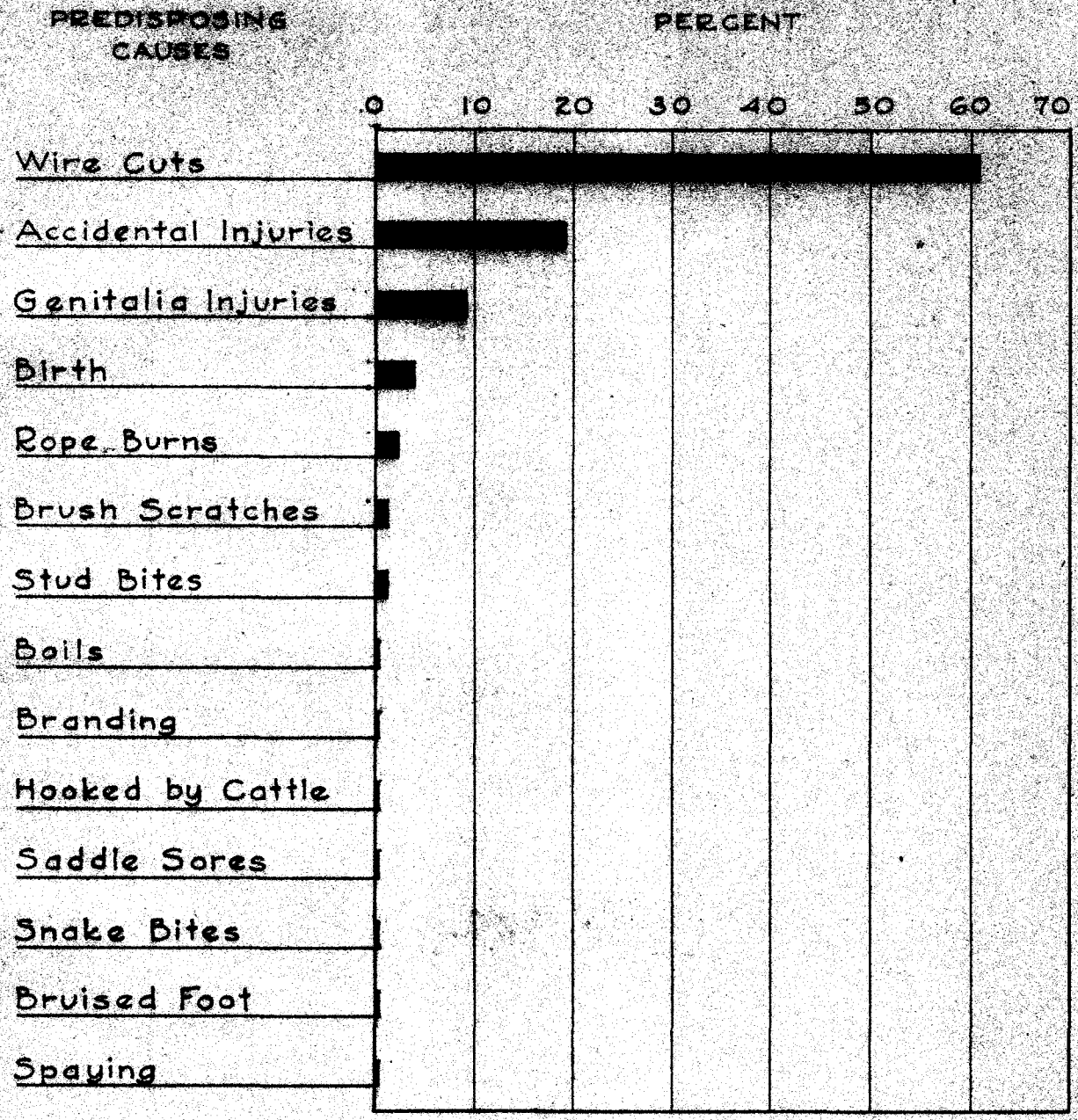

FIG. 7 - DIAGRAM SHOWING PERCENTAGE CONTRIBUTION TO TOTAL OF 358 PREDISPOSING CAUSES OF MYIASIS IN HORSES AND MULES

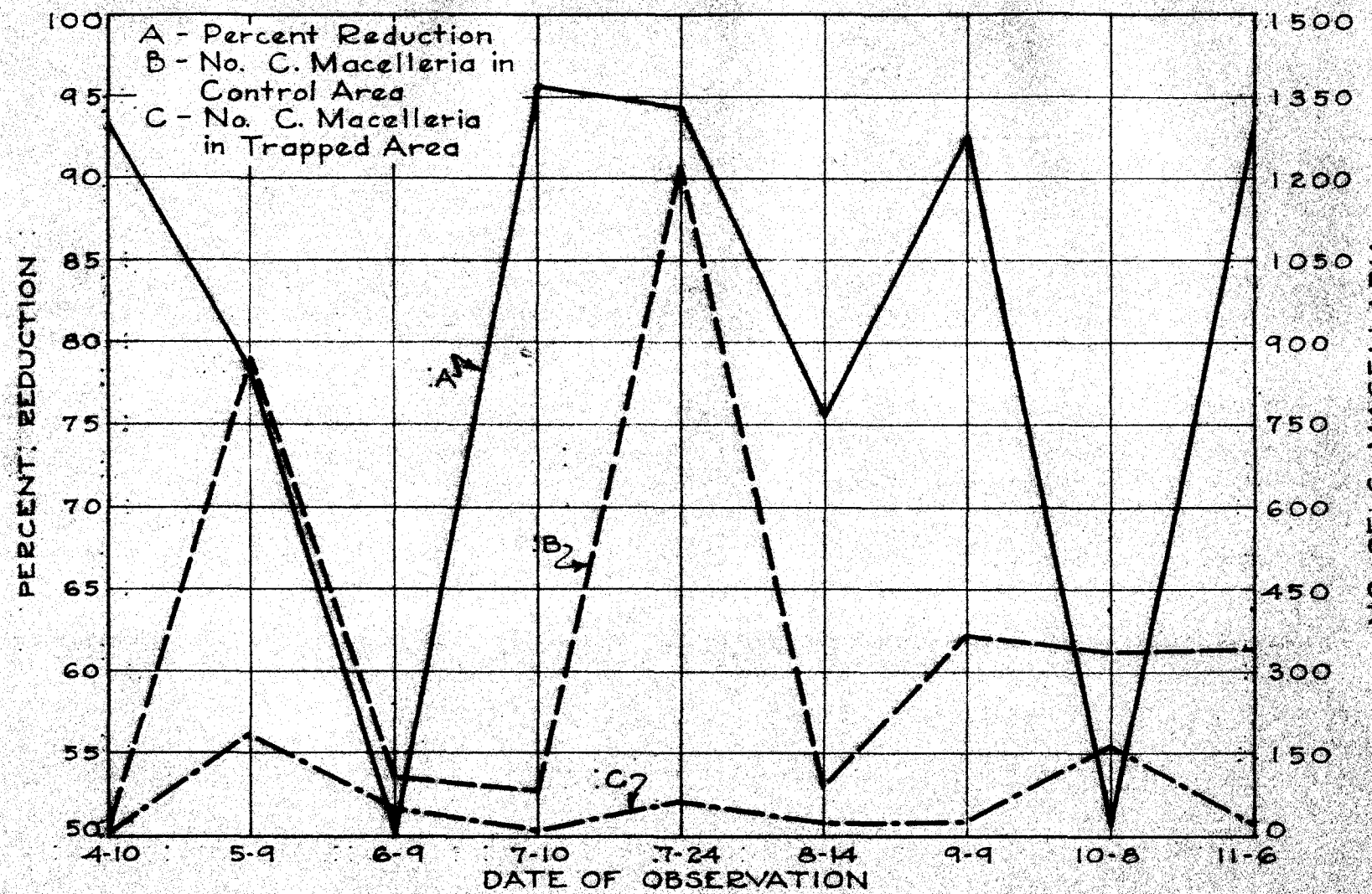

FIG. NO. 8 - SHOWING RELATIVE NUMBERS OF C. MACELLARIA IN THE TRAPPED AND CONTROL AREAS AND THE PERCENT REDUCTION OF C. MACELLARIA IN THE TRAPPED AREA AS DETERMINED BY THE JAR METHOD FOR THE PERIOD APRIL 10 TO NOVEMBER 6, 1931.

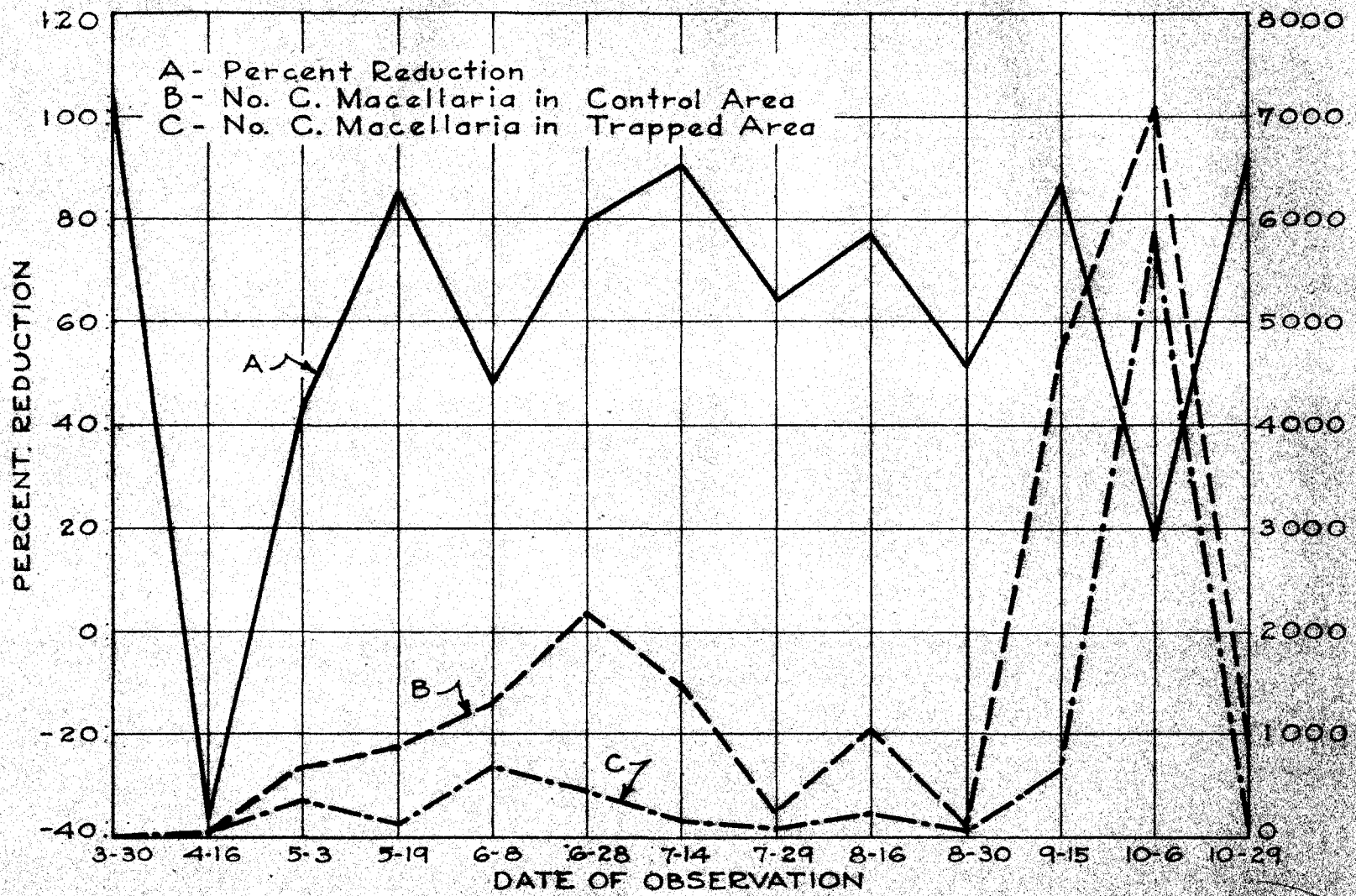

FIG. NO. 9 - SHOWING RELATIVE NUMBERS OF C. MACELLARIA IN THE TRAPPED AND CONTROL AREAS AND THE PERCENT REDUCTION OF C. MACELLARIA IN THE TRAPPED AREA AS DETERMINED BY THE UAR METHOD FOR THE PERIOD MARCH 30 TO OCTOBER 29, 1932.